REMARKS

Further and favorable reconsideration is respectfully requested in view of the foregoing amendments and following remarks.

Claim Amendments

Claim 1 has been amended to recite "rolling" as a positive active step, as suggested by the Examiner. Claims 7 and 8 have been amended to change "rolling set temperature" to "chosen rolling temperature", as suggested by the Examiner.

Additionally, the claims have been amended to make editorial changes, in order to better comply with U.S. practice.

Accordingly, no new matter has been added to the application by the above-discussed amendments.

Claim Objections

The objection to claim 1 is respectfully traversed for the following reasons.

Initially, the Examiner takes the position that the units in the equation for the rolling condition parameter Z do not cancel out. Applicants respectfully disagree.

The units of each parameter in equation 1 are as follows:

$$Z=\log[(\varepsilon/t)\exp\{Q/8.31(T+273)\}] \quad (1)$$

$$=\log[(\varepsilon/t)\exp\{Q/R(T')\}]$$

      ε [-] : strain

      t [sec] : time, which is total time required to rolling

      Q [J/mol] : activation energy for self-diffusion of Fe atom

      T [$^{\circ}$C] : rolling temperature, that is, chosen rolling temperature

      T' [K] : absolute temperature

      R [J/mol-K] : gas constant

The right-hand side of equation 1 is dimensionless because it is a logarithm.

Additionally, the Examiner asserts that no definition of "Q" is provided.

One of ordinary skill in the art would understand that Q represents the activation energy for self-diffusion of Fe atom, as explained in paragraph [0032] of JP2002-54670P (prior application 1), which is mentioned at the end of page 3 of Applicants' specification. A copy of a JPO machine translation of paragraph [0032] is attached hereto.

The value of Q can be obtained by literature references, such as the metallic data book. (Cf. bcc iron: 254,000J/mol, fcc iron: 300,000J/mol.)

Accordingly, the above-discussed objection to claim 1 should be withdrawn.

Rejection Under 35 U.S.C. § 112, Second Paragraph

The rejection of claims 1, 7 and 8 as being indefinite under 35 U.S.C. § 112, second paragraph has been rendered moot by the above-discussed claim amendments.

Patentability Arguments

The patentability of the present invention over the disclosures of the references relied upon by the Examiner in rejecting the claims will be apparent upon consideration of the following remarks.

Rejections Under 35 U.S.C. § 103(a)

The rejection of claims 1-10 and 13-20 under 35 U.S.C. § 103(a) as being unpatentable over Fujioka (JP09-279233 machine translation); as well as the rejection of claim 11 under 35 U.S.C. § 103(a) as being unpatentable over Fujioka combined with Sakata (JP 2001-214214 English abstract); and the rejection of claim 12 under 35 U.S.C. § 103(a) as being unpatentable over Fujioka combined with Saito (JP 60-200915 English abstract) are respectfully traversed for the following reasons.

Applicants' invention provides an <u>industrially useful</u> manufacturing method of ultrafine particle steel, which is excellent in strength and ductility, and has a grain size of 3 μm or less. The method of Applicants' invention is a technique without limitation in either the pass duration or the strain speed. Applicants' invention also provides a technique for controlling the particle

size to 1 μm or less, explicitly. This is based on the findings that it is necessary to control the cumulative strain in multi-pass rolling, processing temperature, strain speed, and pass duration comprehensively, not individually, in order to form an ultrafine crystal structure, and that the grain size depends on parameter Z represented by processing temperature T and strain speed ε/t, as expressed in equation (1) of Applicants' independent claim 1.

On the contrary, Fujioka (which is referred to as document 3 in Applicants' specification) provides a manufacturing method of ultrafine particle steel <u>with limitation in both the pass duration and the strain speed</u>, which is difficult to apply industrially.

Accordingly, Applicants' invention is quite different from the teachings of Fujioka.

The distinctions between Applicants' invention and the teachings of Fujioka are explained in detail below.

1) Definition of the strain speed

In Fujioka, the strain speed at each pass is calculated wherein the denominator is time when the material is deformed by the roll, and the numerator is strain (deformation volume), and it is limited to from 0.1 to 20/second. For instance, "s(s-^{1})" in Table 2 of the reference shows the average strain speed of each pass, see footnote (*2). Therefore, the strain speed changes at each rolling pass. The pass duration is also limited within 20 seconds.

In Applicants' invention, a general and convenient strain speed is used, and is calculated, wherein the denominator is total rolling time including the pass duration and the numerator is total strain. <u>The strain speed is not limited to a specific range</u>. Moreover, the crystal structure control is enabled by calculating the parameter Z by using the strain speed. Only the <u>total rolling time</u> and <u>total strain</u> have to be controlled in Applicants' invention, and it is industrially more advantageous compared to Fujioka, where it is necessary to control the strain speed at each rolling pass. Additionally, in Applicants' invention, the pass duration need not be restricted if Z is in a prescribed range.

2) Control by parameter Z

In Applicants' invention, as shown in Figure 1, the average grain size of the ferrite can be

controlled to the desired value of 3 μm or less according to Z. Fujioka fails to teach or suggest controlling the grain size of the ferrite. In Applicants' invention, a steel material with the desired strength level can be manufactured by controlling the grain size of the ferrite, and the industrial advantage is extremely large.

Applicants have discovered crystal structure control by parameter Z, by using a general strain speed which includes the pass duration.

3) Temperature control

In Applicants' invention, the importance of temperature control of the material between before and after rolling is clearly presented, based on the knowledge that the temperature change of the material brought as the result of processing heat generation and heat removal has a large and unexpected influence on the grain size. The temperature change of the material between before and after rolling at each pass is controlled within 100K to obtain the desired grain size.

Comparative table

	Principle of Grain Refinement	Working temperature	Strain speed	Strain speed	Pass duration	Rolling condition parameter	processing heat generation & heat removal	Grain size of ferrite
The present invention	recrystallization	350-800°C	no requirement	($\geqq 1.5$ claim 10)	no requirement	$Z \geqq 11$	Within 100K	$\leqq 3\mu m$
Fujioka	recrystallization	500-700°C	0.1-20/sec	0.8-5.0	$\leqq 20sec.$	no requirement	no requirement	$\leqq 1\mu m$

It is clear from the above discussion and the above comparative table that Fujioka fails to teach or suggest the method recited in Applicants' independent claim 1, and dependent claims 2-10 and 13-20.

Additionally, since claims 11 and 12 are directly dependent upon claim 1, the subject matter of these claims is patentable over Fujioka for the same reasons that the subject matter of claim 1 is patentable over this reference.

The Examiner has relied on Sakata as disclosing an apparatus for the thermo mechanical

treatment of steel, wherein the apparatus includes a multidirectional roll stand for the rolling step.

The Examiner has relied on Saito as disclosing a process comprising the rolling of steel wherein the rolling speed and draft are controlled to improve the steel structure.

It is clear that neither of these references remedies the deficiencies of Fujioka, as discussed in detail above. Accordingly, claims 11 and 12 are patentable over the cited combinations of references.

For these reasons, the invention of Applicants' pending claims is clearly patentable over the cited references.

Double Patenting Rejection

Regarding the provisional rejection of claims 1-20 on the ground of non-statutory obviousness-type double patenting as being unpatentable over claims 1-20 of co-pending Application No. 10/557,416, Applicants intend to file a Terminal Disclaimer, if necessary. Accordingly, Applicants respectfully request that the Examiner hold this rejection in abeyance, pending an indication that the claims of the present application are otherwise in condition for allowance.
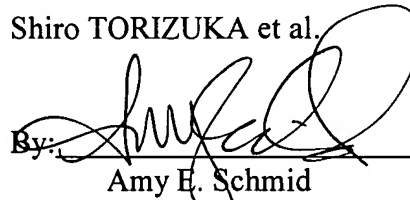
Conclusion

Therefore, in view of the foregoing amendments and remarks, it is submitted that each of the grounds of objection and rejection set forth by the Examiner has been overcome, and that the application is in condition for allowance. Such allowance is solicited.

If, after reviewing this Amendment, the Examiner feels there are any issues remaining which must be resolved before the application can be passed to issue, the Examiner is respectfully requested to contact the undersigned by telephone in order to resolve such issues.

Respectfully submitted,

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Attachment

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(54) METHOD FOR MANUFACTURING THICK STEEL PLATE HAVING HYPERFINE GRAIN STRUCTURE, AN THICK STEEL PLATE

(57)Abstract:

PROBLEM TO BE SOLVED: To provide a method for manufacturing a thick steel plate having a hyperfine grain structure, which has a strength enhanced by micronizing grain sizes to 1 μm or less, without adding any alloying element, and can contribute to the environment and the recyclability, and to provide the thick steel plate having the hyperfine grain structure in which the grains have micronized sizes of 1 μm or less, and are surrounded by large-angle grain boundaries.

SOLUTION: The method for manufacturing the thick steel plate having the hyperfine grain structure is characterized by subjecting a steel material to multidirectional multi-pass warm rolling in a temperature range of 350-750° C, which makes at least two of accumulated reduction strains εT, εW, and εL, respectively in a thickness direction, a width direction, and a longitudinal direction of the plate, which are shown in equations (1)-(3), to be 0.3 or more, and makes the total accumulated reduction strain εT+εW+εL to be 1.8 or more, (where RT,i,RW,i, and RL,i respectively indicate a rolling reduction of the i-th reduction pass (%) in the thickness direction, the width direction, and the longitudinal direction of the plate).
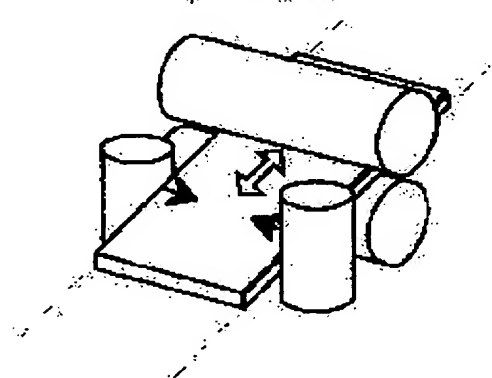
invention of this application is a following formula (4) by a crystal structure of Fe in steel materials simpler and certainly as an index for [of desired mean particle diameter] overly obtaining a detailed seed crystal organization.

[0031]
[Equation 8]

$$Z = \log\left[\frac{(\varepsilon_T + \varepsilon_W + \varepsilon_L)}{t}\exp\left(\frac{Q}{8.31(T+273)}\right)\right] \quad (4)$$

[0032]He comes out and is trying to control the value of the rolled bar affair parameter Z shown. t in a formula shows the time (s) from a rolling start to an end, T shows the average (**) of rolling temperature (**) or the rolling temperature of each path, and Q shows the activation energy of the self-diffusion of Fe. It is clear that mean particle diameter's of a super-fine grain formed by old research by the strong processing in the temperature region between ** by the invention of this application it is dependent on rolling temperature (T) and a strain rate (epsilon$_T$+epsilon$_W$+epsilon$_L$) (/t) to some extent. Minuteness making of this average crystal grain diameter can be carried out with the increase in the processing-conditions parameter Z by the upper type (4) which is a function of working temperature and a strain rate. In the invention of this application, when it is the crystal structure bcc of Fe in start steel materials (i.e., when making a ferrite, bainite, martensite, or perlite into a host phase), Q in an upper type (4) is set to 254000, and the rolled bar affair parameter Z adjusts in the 11 or more ranges, and is made to perform multiple-directions pressing-down ***** path rolling. In order to make austenite into a host phase when the crystal structure of Fe in steel materials is fcc namely, Q in an upper type (4) is set to 310000, and the rolled bar affair parameter Z adjusts in the 20 or more ranges, and is made to perform multiple-directions pressing-down ***** path rolling. When this rolled bar affair parameter Z is about 11 of the above-mentioned critical value, and less than about 20, respectively, since an organization with a mean particle diameter of 1 micrometer or less may be unable to be obtained, it is not desirable.

[0033]He is trying for parameter f/d showing a distribution state of the 2nd phase to use steel materials which have 0.03 or more diplophase organizations as steel materials in a manufacturing method of steel plates which have a super-fine grain organization of an invention of this application. Here, f shows a molar fraction of the 2nd phase and d shows an average diameter (micrometer) of the 2nd phase. As the 2nd phase, can take into consideration carbide, such as cementite, perlite, martensite, bainite, austenite, etc., therefore as a start material, For example, steel materials which have an organization of "ferrite + perlite", "ferrite + cementite", "ferrite + martensite", "martensite and bainite + cementite (tempering martensite, bainite)", etc., etc. can be used. Thus, by using for an organization in front of processing and under processing steel materials which the 2nd phase is distributing as a start material, distribution of presentation distortion localizes micro and formation of micro partial orientation difference accompanying distorted introduction is promoted. And since this micro partial orientation difference serves as the generation origin of a super-fine grain, it can realize more efficiently promotion of formation of a super-fine grain, and by extension, an increase in a rate of a big square grain boundary by increasing partial orientation difference. Here, as for the 2nd phase, it is desirable to distribute as so much as possible and minutely. When parameter f/d using the 2nd phase molar fraction f and the average diameter d is less than 0.03, a rate of a big square grain boundary is low, and since an ideal super-fine grain organization in which ***** remained and which was excellent in a mechanical property is hard to be formed, it is desirable [f/d] to use 0.03 or more.

[0034]In addition, a manufacturing method of steel plates which have a super-fine grain organization which an invention of this application provides is characterized by rolling so that accumulation pressing-down distortion of a rolling pass in the same continuous pressing-down direction may become 0.3 or more. This is because an effect of multiple-directions processing of a way which performs pressing down of a uniform direction continuously to some extent rather than pressing down various directions by turns shows up easily, when rolling reduction per one pass is small. Such a pressing-down path of a continuous uniform direction is illustrated as what